DOCUMENT RESUME

ED 252 396 SE 045 315

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TITLE Experimenting with an Alternative Teaching Approach on "Metals." Learning in Science Project (Primary). Working Paper No. 113.
INSTITUTION Waikato Univ., Hamilton (New Zealand). Science Education Research Unit.
PUB DATE Jul 83
NOTE 35p.; For related document, see SE 045 303.
PUB TYPE Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Comprehension; Concept Formation; *Curriculum Development; Elementary Education; *Elementary School Science; Foreign Countries; Learning Strategies; *Metals; Questioning Techniques; Science Education; *Science Instruction; Science Projects
IDENTIFIERS *Learning in Science Project (Primary); *New Zealand; Questions; Science Education Research

ABSTRACT

An alternative approach for teaching primary school science has been proposed by the Learning in Science Project (Primary--LISP(P). This study investigated the use of the approach during three series of lessons on the topic "metals." Each series followed the same general pattern: (1) an introductory session to stimulate children to ask questions about metals, followed by opportunities to (2) answer or explain the questions, (3) investigate whether or not their questions/explanations were good ones, and (4) report findings to the rest of the class. Data were collected from observations and audiotape recordings of classroom interactions, individual student interviews, and from student worksheets (samples of which are included in an appendix). Areas examined focused on: the form of stimulus appropriate for this topic; which questions/explanations should form the basis of student investigations; whether appropriate resource materials are available; whether primary children have investigatory and processing skills adequate to the task; whether children are interested in the topic or reports of other students; what children actually learn; and what are the teacher's experiences in using the approach. Selected results show that students could be stimulated to ask questions, were interested in the topic, but seemed to lack the necessary thinking and investigation strategies. (JN)

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EXPERIMENTING WITH AN ALTERNATIVE TEACHING APPROACH ON 'METALS'

SE 045 315

Science Education Research Unit
University of Waikato
Hamilton, N.Z.

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Working Paper No. 113

UNIVERSITY OF WAIKATO

EXPERIMENTING WITH AN ALTERNATIVE TEACHING APPROACH ON 'METALS'

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July 1983

A Working Paper of the Learning in Science Project (Primary)

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INTRODUCTION

A number of problems relating to the teaching and learning of science at the primary school (8-11 year) level identified by the LISP(P) seemed to require for their resolution, among other things, an approach to teaching that was different from one in which the teacher either tried to transfer scientific knowledge from himself to the child, or simply engaged the children in various activities. An alternative teaching approach that was proposed (Biddulph & Osborne, 1982) is reproduced as Figure 1.

FIGURE 1: Proposed alternative teaching approach for primary science

Step 1: CHILDREN IN INTERESTING SITUATION

A situation that stimulates the children to ask questions related to a science topic.

Step 2: CHILDREN'S QUESTIONS ON THE TOPIC

These could be publicly recorded eg. on the board

Step 3: CHILDREN'S SUGGESTED ANSWERS TO A QUESTION

These could be written on paper by the children either individually or in groups and if desired then also listed on the board.

Step 4: CHILDREN'S RESEARCH PROPOSALS

At this step the children either individually or in groups write a research proposal outlining:

(a) the question/answer they are going to check on
(b) how they are going to check on it
(c) where they are going to check on it
(d) how long they estimate they will take
(e) what equipment they will need

Teacher approval will be necessary before children embark on Step 5. (A teacher may decide to accept some proposals that are doomed to failure but from which children will learn something useful.)

Step 5: CHILDREN'S RESEARCH ACTIVITY

The children conduct an inquiry on their problem using their suggested activity. This may be

(a) observation or 'experiment'
(b) consulting books
(c) consulting knowledgeable people

Step 6: CHILDREN'S RESEARCH REPORT AND PEER COMMENTS

The children report their findings to the rest of the class. The other children, with teacher guidance, comment on

(a) whether or not the group or individual had really found out what they were trying to find out
(b) possible alternative explanations
(c) other studies that might follow

A class teacher's first attempt to use this approach for primary science teaching was described in Biddulph and Roger (1983). The experiences gained from this initial exploration of the proposed alternative teaching approach suggested that a more detailed investigation should be made of its potential use in the primary classroom for teaching science.

This paper describes the possibilities and problems encountered when three series of lessons were taken in March/April 1983 with three different S.3 classes on the topic 'metals'. Variations of the proposed alternative teaching approach were used. The first series was taken by one of the authors (B.M.) who was the teacher of the class, while the second and third series were taken by the other author, the researcher.

The classes involved in the first and third series of lessons were average to above average in ability, while the class involved in the second series contained children of mixed ability.

During the first series of lessons (six in all) data were obtained by participant observation by the teacher, by observation by the researcher who was present in the classroom throughout the lessons, by observation by three assistant researchers who were present during one lesson, by recording on audio tape small group and whole class discussions, and by the researcher interviewing the children individually before and after the first lesson, and at the conclusion of the series.

During the next two series of lessons (four lessons in each case) data were obtained by participant observation by the researcher, by observation by the two class teachers, by recording on audio tape small group and whole class discussions, and by collecting worksheets on which the children had recorded their ideas. (Two forms of the worksheet used are shown in Appendix 1.)

Each series of lessons followed the same general pattern, namely

(i) there was an introductory session to stimulate the children to ask questions about metals;

(ii) the children, in small groups or individually (as they chose), wrote possible answers to one or more of the questions;

(iii) the children chose one or more questions/explanations and carried out an investigation to check whether or not they were good ones;
(iv) the children reported their findings to the rest of the class.

A number of issues emerged during the first series of lessons taken by the class teacher. The researcher attempted to address some of these during the second and third series of lessons. The issues may be summarised as:

(i) What form of stimulus is appropriate for this topic?
(ii) Which of the children's questions and explanations should form the basis for their investigations?
(iii) Are appropriate resource materials readily available on this topic for children of this age?
(iv) Do childen of this age have investigatory and processing skills adequate to the task?
(v) Are children interested in the reports of others?
(vi) Do children show interest in the topic?
(vii) What do the children learn?
(viii) What is the teacher's experience, especially his sense of control of the teaching/learning situation, using this approach?

The remainder of this paper explores these issues in the context of the three series of lessons. The children's ideas about 'metals' have been reported elsewhere (Biddulph, 1983) and mention will be made of these only in so far as they have been changed (or otherwise) by factors in or emanating from the classroom teaching/learning environment.

STIMULATING CHILDREN'S QUESTIONS

Prior to lesson one of the first series, the teacher was supplied with two types of information, namely
(i) The number of children in his class who thought that various metal objects were or were not made out of metal as disclosed in individual interviews with the researcher. For example, half the number of children thought a 2¢ coin was not made out of metal, or they were not sure whether it was or not and
(ii) The most common questions that other children of this approximate age level had asked about 'metals'.

On the basis of this information the teacher decided to use what might be described as a class interview-about-instances techniqiue as an introductory activity. Various common objects were shown to the class one at a time and the children were invited to say which group 'things made of metal' or 'things not made of metal', they would put each object in. When all objects had been dealt with in this way, amid considerable discussion as might be imagined, the children were invited to ask questions about metals. Every child responded and 31 questions were asked, the most popular being,

"How can we tell if objects are really metal?"

Interestingly, of the 18 questions asked by the children during individual interviews with the researcher a day or so prior to the lesson only three similar questions were asked in the class situation relating to the origin, colour and shaping of metals. It seemed that 15 of their previous questions had been forgotten, to be replaced by 28 new ones. Three of the children had previously asked questions about magnets and metals but no question relating to magnets was raised by the children in class. On the other hand, five questions to do with the history of metal (for example, "Who invented metal?" "Was metal used in the olden days?") were asked in class but no such questions were asked during the interviews. The difference could not be wholly explained by the different stimulus situations as in both cases the children's questions went beyond the stimuli in many instances. Perhaps it was a function of the children bringing a set of expectations to the classroom lesson which differed from that which they brought to the interview situation.

In the second and third series of lessons, taken by the researcher, a slightly different approach was used. Given the previous teacher's experience and thoughts on the matter, the researcher sought to establish with the children at the outset what <u>he</u> meant when he was using the term 'metals'. Like the teacher he took into the classrooms a number of common objects made of metal (for example, a gold ring, silver spoon, stainless steel knife, aluminium milk bottle top) and showed them to the children one at a time. This time, however, he told the children that the objects were made of gold, silver, steel (as the case may be) and that these were metals. The children were asked to offer any comments they might have and it became clear from these that many had not

previously thought of a number of the objects (particularly the aluminium foil) as being made of metal. When they were then invited to ask questions about 'metals' the second class of children responded with 15 questions initially and another 25 questions in a later lesson, while the children in the third class asked 35 questions.

Despite the variation in the approaches used by the teacher and researcher both resulted in children generating a considerable number of questions.

CHOOSING CHILDREN'S QUESTIONS & EXPLANATIONS FOR INVESTIGATION

The problem of how to choose a suitable question or questions for further study by the children was not really resolved during the three series of lessons.

During the first series the teacher decided to let the children, in their groups, choose which questions they would like to propose answers to. The result was that the children chose to answer 17 of the 31 questions, with some groups answering several questions. The teacher felt that this was a bit unmanageable and he therefore selected four of the children's questions for further investigation (see Table 2).

TABLE 2: Questions chosen by class teacher for investigation

1.	How do you make metal?
2.	How can we tell if objects are really metal?
3.	Why is aluminium light?
4.	Are many boats made from metal?

The teacher chose these questions for various reasons. He thought that question 1 and 2 would help the children gain basic understanding about metals, he wondered what would happen if children attempted question 3, and question 4 was included because it proved a popular question when the children in their groups chose questions to answer. The teacher then had the children, again in their groups, choose one of the four questions on

which to do further work. He wanted them to find answers to the questions and suggested that they might look in books, ask people, or think up some experiments to do.

Mindful of the teacher's experience of being confronted by the children choosing to answer a relatively large number of the questions, the researcher decided to choose one of the children's questions in each case for further study during the second and third series of lessons. In the second series the question chosen was,

"How do you make metal?"

and in the third series it was,

"Where does most metal come from?"

The basis on which these questions were selected was the researcher's idea, as he stood before the children glancing down the list of questions, that they might somehow lead the children to some basic understanding of metals. He also knew that these questions were commonly asked by children of this age. When the children in their groups were invited to suggest possible answers to these questions they responded with many answers. The researcher later collated these and wrote them on the board.

For the next part of these latter two studies the groups of children were provided with a small worksheet to guide them. In the second series they were asked to write an answer(s) from the board that they would like to check on to see if it was a good one or bad one. The worksheet was modified for the third series of lessons to try to focus the children on those answers from the list that they considered to be sensible ones to the questions. This time they simply had to record the number of the answers they considered sensible but beside each they had to write their reason for choosing it.

Many of the questions asked by the children, for example,

"Why is metal used so much?"

"What metals can you mix together?"

"Can you mix metals with glass?"

"How do they make it go so flat like foil?"

could be answered through reading about them or asking people who knew. With hindsight, some of their questions which were not dealt with would

probably have provided a better basis for scientific investigation than a number of those chosen. Examples of these are listed in Table 3.

TABLE 3: Children's questions about metals that could have provided a good basis for scientific investigation.

1. Is there any kind of metal that can float?
2. How long does it take to shape metal?
3. Is there any kind of metal that will absorb heat?
4. Are cars (tiles, heaters, etc.) metal?

It should be added that these were about the only other questions that could lend themselves to scientific investigation although with a little amendment some of the children's other questions would have provided a good basis for scientific investigation as well; for example, "How does metal stick to magnets?" could have been rephrased as, "Does metal stick to magnets?" and the question, "Can any metals prevent rust?" would have been better reworded as, "Can we prevent metals from rusting?"

> The experience of the three series of lessons suggests that if teachers are to use children's questions and explanations as a basis for teaching primary science then they are likely to require clear guidelines as to how they can choose questions for investigation.

RESOURCE MATERIALS FOR CHILDREN'S RESEARCH

The resource materials used during the first series of lessons were,
(i) common metal objects or pieces of metal brought to school by both teacher and children;
(ii) pieces of metal from the school science resource kit;
(iii) pieces of various kinds of metal ore supplied by the researcher;
(iv) books acquired by the teacher from the school library and country library service, and books brought to school by the children.

In the second and third series of lessons common metal objects were again used and children again brought books to school. The ore samples were

used in the second series of lessons but dropped from the third series because it was felt that teachers would not normally have access to such samples.

Although in the first series of lessons the teacher and children had gone to considerable effort to provide the best collection of books available the books nevertheless proved to be a bit too difficult for the children. The children could say the words but they did not have the background to understand many of them. Furthermore the texts were not really addressed to the things about which the children were interested and consequently they were of little use to them in answering their questions.

For the second series of lessons the researcher decided to write hurriedly a small resource booklet using the type of language that would be familiar to nine-year-old New Zealand children and based on the four most common questions that children at this age had asked about metals. (The booklet is reproduced as Appendix 2.) When the booklet was introduced to the second class one group of children out of eleven copied information from it but nine groups used it to gain information which they structured in their own words on the worksheets provided. For example, in the first paragraph of the resource booklet there was a sentence which, with reference to metals, stated:

> "You can also see how some may be joined together to make new metals or <u>alloys</u> as they are called."

A diagram on the following page illustrated this. One group of children used this information to write on their worksheet,

> "Also, some metals can be mixed to make other metals, such as copper and zinc makes brass."

A similar thing happened with the third S.3 class who were also provided with the booklet; two groups of children out of fifteen copied from it but twelve groups restructured the information. One group in each of the two classes worked from encyclopaedias or their own books rather than from the resource booklet but they tended to copy sentences from their own materials and had a struggle to read them, let alone understand them. For example, one group wrote on their worksheet,

> "Some metals are formed in the pure state but most of them are found in combination with other elements. These metals are in the form of sulphides, oxides, carbonates, and silicates usually mixed with rock and earthly materials."

Not surprisingly, one boy who listened to this commented,

> "I don't understand what none of it says."

Although the children's worksheets revealed that almost all of the children who used the resource booklet interpreted the information in the way intended by the researcher, there was an instance during the second series of lessons when this did not occur. A group of two boys told the researcher that the lead in their pencils was a kind of gold, and when the researcher asked them how they knew, they said that they had read it in the booklet. Perhaps they linked the carbon and diamonds mentioned in the booklet (as related to graphite) to the precious metal gold, also mentioned.

In some cases the children seemed to successfully use their parents as resource people. For example, during the second series of lessons three boys, whose reading level was very low according to their teacher, had nevertheless managed to record on their worksheet with respect to the question 'How do you make metal?'

> "My dad said that they dig it up, then they squash it. Then they put it into the shape that they wanted."

There were a few children, however, (four during the first series of lessons) who reported that their parents hadn't proved very helpful in this respect.

On the whole, the use of such resources as common objects and people seemed to function well but the present availability of suitable written resources on this topic for children of this age must be in doubt.

CHILDREN'S INVESTIGATIVE AND PROCESSING SKILLS

Early in the first series of lessons the teacher expressed some reservations about his children's research skills being equal to the task, even though they were reasonably able children and had previously worked to develop some of the skills. Observation of the children at

work suggested that the teacher's reservations were justified. The tendency of a few children to copy from encyclopaedias sentences which they did not understand was noted by two of the research assistants, one of whom also noted that when one group of children had done this they made no attempt to use any of the other resource books provided. The three research assistants reported that in several groups much verbal exchange centred around practical organizational matters, such as the use of felt-tip pens, rather than on the subject matter. The third research assistant also reported that in a group that she observed closely the five or so children did not function as a unit; they broke into two or three sub-units with each considering a different object at any one time. This occurred during a guided activity set by the teacher where the children were testing various objects to see whether or not they were made of metal. The research assistant also noted that the use of the scientific method by the children deteriorated in quality as the activity continued until the children reached the stage where they were using their preconceived ideas to determine whether or not an object was made of metal. For example, during the early part of the activity one boy looked at the rim of a magnifying glass and decided,

"That's metal 'cause it's already shiny."

Later, when three of the children were considering a ring, their investigation took the form of verbal assertions.

P_1: "I think it's gold."

P_2: "I don't."

P_3: "It doesn't look real. I don't think it's gold."

P_2: "It looks like platinum."

On the basis of this reference to 'metals' one child concluded,

"Yeah, it is metal."

and the other two children concurred with this.

One of the tests which the teacher suggested the children use during this activity was to tap the object to see if it made a ringing sound. One child whom the teacher observed and two whom the researcher observed didn't seem to appreciate what was involved in the use of this testing process. The first child simply waved an object in the air and said,

"This doesn't make a ringing noise."

The other two used a tuning fork to test various objects and then held the tuning fork to their ear; everything they tapped seemed to be made of metal!

Another example of children's use of inadequate research or investigation strategies was the activity of two girls who located 'aluminium' in the index of a book but then, in both trying to turn the pages, arrived at the wrong page and concluded (in the words of one of the girls),

"There's nothing here."

A further example was a boy who read to the researcher his finding that an oil tanker is made of copper. When the researcher asked him how he knew, he borrowed a book from another boy, found a picture of a tanker, confidently pointed to the title on the front and announced to the researcher,

"Because the whole book's only about copper."

He added,

"It's all about copper, so it's got to be copper."

Another type of thinking strategy used by most of the children during the second series of lessons was to revert to trying to find the 'right' answer to the original question when they were supposed to be checking whether a particular explanation was a good one or bad one. Nine of the eleven groups of children ignored the explanation entirely and when a child in one of the two remaining groups referred to it when reporting back she was laughed at because, as one boy explained to her,

"It's um, not even talking about the (metal) liquids. You're just talking about the answer ... that's on the board."

Significantly, the other group which did consider the explanation omitted the last sentence of their findings when they read their report. The sentence read,

"It is a good answer because some metal alloys are made that way."

The children's inadequate prior knowledge and processing strategies showed in their efforts to design and conduct experimental-type investigations and this was the case in each of the three classes. There were examples of children who were prepared to conclude that an object was made of metal if it went rusty in the water (but was not made of metal if it didn't) and if it stuck to a magnet (but was not made of metal if it didn't). Two boys found a piece of metal shaped like a canoe, tried it to see if it would float - which it did - and on the basis of this 'experiment' reached the conclusion that <u>many</u> boats are

made of metal. Another boy suggested that one way to check whether or not foil was metal was to tear some in half and look at it under a microscope. He seemed not to realise that one would require certain criteria by which to make a judgement about what one was viewing.

The children's lack of understanding of the purpose or critical element of experimental investigation was further illustrated by a discussion between the boy who mentioned the copper oil tanker and his partner. After concluding that boats would not be made of aluminium (they would be 'all dented up if they banged against a pole') but would be made of iron (layers of very light corrugated iron all 'smoothened' out and welded together) they suddenly decided to follow one of the teacher's suggestions and design an 'experiment'.

P_1: (speaking to second boy) We'll do our experiment now.

P_2: But I don't know any experiments.

P_1: Oh, I know, I know, get a bit of iron and then you paint it and let it dry, and scrape off the paint, and then put it in water and see if it rusts, in salt water 'cause that's where you usually find boats.

There is no sense of controlling anything in this proposal, only a sense of doing something.

Of the 'experimental' investigations that the children were observed to design and engage in themselves none went beyond activities based on a sense of what could be done with particular metals, or what would happen to them if they were treated in a particular way. For example, during the third series of lessons two children worked with aluminium foil to see what shapes they could make and eventually showed the class a miniature 'hammer', small 'tray', some silver 'balls' and a model 'sailing boat'. Another child said that she tried to use a hammer and chisel to chip a bit of metal out of a big plate of metal but she did not get very far she told the rest of the children; she only made a little mark. A fourth child showed the class group his 'experiment' which consisted of two jars each containing a soapy liquid and a small quantity of iron filings. Into one he had put a piece of lead and into the other he had placed a piece of aluminium. He explained that he was keeping them for a few days to see what would happen to the lead and aluminium.

There was an occasion during a researcher-guided discussion in the third series of lessons when a group of children demonstrated an ability to think through an issue themselves. The researcher recalled to the children that the previous day a group had found out that nobody actually invented metal. Five children talked about the matter as follows:

P_1: Why?

P_2: But just after the cave men it would be.

P_3: They just, who invented

P_4: If we didn't invent it, we wouldn't have it right now, so I don't really understand.

P_5: No, nature made it. Nature put the rock there, so it's really nature. It could have been there when the cave men were there.

P_4: (a few moments later) If nobody invented metal then it sort of leaves another question; who discovered metal?

The observations of these children at work suggest that if children at this level are to conduct meaningful investigations then they will require careful guidance for some time. The question of group size also seems to be important. In the second and third series of lessons the number of children in each group was limited to a maximum of three, and the groups did seem to function as groups.

CHILDREN'S REPORTING OF, AND INTEREST IN, THEIR FINDINGS

During the first series of lessons, when different groups of children investigated one of four questions, the teacher usually concluded each lesson with the children meeting as a class group to report some of the things that they had done and found out. The children generally listened with interest during these relatively brief report sessions.

During the second series of lessons, when the groups of children chose various suggested answers to check on, the researcher tried to hold a more formal type of reporting-back session as the last lesson and invited other children to comment on their findings. However, in this situation the majority of children seemed not to be very interested in what the other groups had investigated, what they found out, or the comments of

the few who offered them. On the other hand they showed close interest when the researcher took up some of their earlier questions, which had not been investigated but to which the children said they were still interested in finding answers, and gave answers where this was possible.

During the third series of lessons the researcher used the first teacher's approach of shorter, more frequent reporting-back sessions, together with a consideration of some of the children's other questions. As with the first series of lessons, the children seemed to listen with interest during these briefer, more informal reporting sessions.

CHILDREN'S RESPONSE AND LEARNING

Apart from the indifference on the part of many of the children to the formal-type reporting back session during the second series of lessons, there was really only one expression of disinterest, but by the end of the series of lessons in which this occurred that child told the researcher,

"I'm glad I know more about metal."

The same child also said that he would like to be told the answers to some of the questions. This was echoed by several other children, and the researcher consequently set some time aside during the second and third series of lessons to deal with those questions which had been left to one side during the study.

Forty-nine children who offered comments said that they liked the lessons and enjoyed learning about 'metals'. Their experience is perhaps summed up in the words of one child in the third class:

> "I thought it was quite interesting and sort of helpful to our lives, 'cause some of us might want to work with metal now and they might have thought in the first place that it is just a boring thing. I learnt quite a lot of things."

In one class nine of the children made specific reference to the questions which they said they really liked.

In the third class the children as a class group took great interest in a test suggested and guided by the researcher, namely the use of an electrical circuit to check whether or not various objects were made of metal.

When questioned about what they thought they had learned, some children from each of the three classes had an idea that they had learned something but what it was they couldn't recall. One girl, for example, said,

> "I'm not quite sure what I've learnt but I know I've learnt something."

Nuthall and Alton-Lee (1982) refer to this type of response as a 'vague feeling of knowing'.

Many children, however, had a clear idea of what they had learned. The thing that most had learned, they said, was that various materials which they had not thought of as beings metals were metals. One boy, for example, put it this way.

> I didn't think copper or aluminium was a metal. I thought metal was just metal and there weren't any different sorts."

Another thing which a number of children (ten in one class) had not realised before was that metals, for the most part, had to be extracted from rock. This was illustrated by one child who said,

> "I didn't know that you got metal out of rocks."

With a few children, the words which came from their mouths did not necessarily convey the meaning they intended. One boy, for example, told the researcher,

> "I found out that lots of things I thought were metals aren't, like gold and steel."

Taken at face value his statement suggests that he had moved away from a scientist's view of metal but this was not so; he had really moved toward it. In the unhurried interview situation the boy expanded upon his statement,

> "I thought they were totally different things. I know that they're metals now."

Another girl seemed to realise that her spoken words were not saying what she intended so she rephrased them.

> "I didn't know that magnets only stuck to some types of metal. I did know that, but I didn't know which types they would only stick to."

There was also evidence of children retaining non-scientific views, despite their involvement in activities intended to provide them with a sound basis for understanding. For example, at the end of the first series of lessons five children still believed that 'heaviness' is an important criterion for determining whether or not an object is made of metal, and one child clung to the view that ability to stick to a magnet is a determining factor. This is consistent with the results of a study by Symington and White (1983) who found that despite their involvement in activities designed to shift their thinking, most 10 year old children in two Australian classes retained the ideas that they brought with them to the lessons.

THE TEACHERS' EXPERIENCES

The reported experiences of four teachers form the basis of the comments of this section. They are the observations of the teacher who took the first series of lessons, the researcher who took the second and third series of lessons, and the two class teachers who were present during the lessons taken by the researcher.

At the beginning of the second series of lessons the class teacher explained to the researcher that the children in her class differed widely in ability. She suggested that when the children worked in groups each group could include some of the less able and some of the more able readers. She accordingly had written a list of possible groups. However, mindful of the experience of a previous teacher regarding compatability of group members (Biddulph & Roger, 1983), the researcher decided to let the children themselves choose with whom they wanted to work. And sure enough, the three least able readers (boys) in the class formed a group! The teacher was somewhat concerned that they might not cope with the reading and written aspects but to her real surprise the three boys among them produced work of which the teacher did not suspect they were capable. The earlier mentioned statement about one boy's father saying that metal was dug up, squashed and shaped was their work.

This same teacher considered at the conclusion of the series of lessons that they had been,

"... a marvellous experience for the kids."

She added,

> "They've really enjoyed looking up things for themselves. I think it's far better than me standing up the front telling them things. They will remember it longer and appreciate it more. I think some of them worked really, really well."

The researcher also felt that the children worked well. On the first day he had to give direction to a group of two boys several times but on the second day he became aware part way through the lesson that all groups were working away quietly at their tasks and that none needed direction as on the first day. The children's response during the final lesson, it seemed to the researcher, supported their teacher's view that they had learned things. With two exceptions, the children did not hesitate to say what they felt they had learned and these learnings were in the direction intended by the researcher.

At the conclusion of the third series of lessons the children's own teacher expressed to the researcher his interest in seeing the children's ideas revealed. He said,

> "I was quite interested in finding out what these kids know about these sorts of things. It's hard sometimes to find it out. You can discuss it but quite often you don't get those sort of ideas because there are four or five actually discussing and the others knock off and take a back seat, and leave the others to do the work."

The desirability of having small groups of children is suggested in the observation of this teacher.

The teacher who took the first series of lessons identified a number of aspects of concern. The lack of suitable written resources has already been mentioned. Another aspect was the time the children required to head up a simple card on which to record their results. The teacher could see value in having a worksheet with printed headings for younger children. In the second and third series of lessons the researcher built upon the teacher's experience and introduced both a booklet and children's worksheets with some success.

Another area of concern to the teacher who took the first lessons was the lack of a clearly defined goal. He experienced a sense of uncertainty

about the direction of the study; he was not sure what he was trying to achieve with the children. Hence he did not know whether to answer some of their questions or to further guide them to find answers for themselves. Towards the end of the series, he decided to guide the children in two activities which he thought would provide them with some worthwhile understanding of metals, namely using specified tests to check whether or not various objects were made of metal, and trying to identify the type of metal contained in several samples provided.

Aspects that concerned the researcher when he took the second and third series of lessons were firstly, the difficulty of deciding which (if any) of the children's questions would provide a worthwhile study and secondly, that the children could not by themselves structure scientific-type investigations. In short, the researcher had reservations about whether any worthwhile learning by the children was taking place.

On the positive side, the teacher of the first series of lessons felt that his children had responded very well and had shown a great deal of interest in the whole approach. He thought that the questions clearly pointed to deep thinking and a desire to know on the part of the children. He was surprised at both the number and depth of the questions asked. He also noted that the study had prompted the children to spontaneously engage in various kinds of research at home. An aspect that he particularly liked was the children's part in designing the study. It gave him insights into their thinking that he felt he had missed previously. He became very aware that in the past he had probably assumed that the children had certain ideas or meanings which in fact they did not have. He now realised, for example, that the term 'metal' probably meant something different to every child in the class.

SUMMARY AND IMPLICATIONS

The efforts of both the class teacher and researcher to use an alternative teaching approach with S.3 children on the topic 'metals' showed that the children could be readily stimulated to ask questions about, and take an interest in, this topic. Without reshaping, however, few of the children's questions would have lent themselves to investigation along scientific lines. Others could have been answered by other means and the children would have appreciated this.

Resources in the form of every day objects made of metal were readily available but written resource material at a level the children could read and understand was not. Written materials may be more useful for some topics than others. If so, the problem of suitability of existing materials with respect to those topics will need to be addressed.

The approach used enabled the teacher and researcher to be more aware of the children's thinking than is usually the case. It revealed that the children seemed not to have thinking and investigation strategies adequate to the task expected of them. Whether they could develop these with teacher guidance is something that would need to be explored.

The question of group effectiveness seemed to be related to group size. There was a tendency for groups consisting of five or six children to break into sub-groups. The experience suggested that a teacher-guided whole class group was an effective form of organization for some learning, while groups of three or less children were effective for other forms of learning. Further work is obviously needed, however, to identify clearly the effects of different sized groups on various aspects of children's learning in science.

Another important issue was the goal of teaching/learning using the alternative approach. Without some clear idea of what one could expect to achieve with the children on this topic, the teacher and researcher experienced some difficulty in handling the children's questions and explanations. It seems clear that teachers are likely to require information about not only the ideas and process strategies that the children are likely to have already, but also the ideas and investigatory strategies that they can develop. In addition, of course, they will probably need suggestions about how they can help them do so.

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ACKNOWLEDGEMENTS

We are most grateful to Roger Osborne and Peter Freyberg for their comments on an earlier draft of this paper.

We would like to thank Mr Trevor Kilpin, Mr Colin McCormack, Mr Kevin Sheppard (Hamilton) Mr Trevor Crewe and Mrs Williams (Christchurch) for welcoming us into their schools and classes. We also express our appreciation to the children who worked with us.

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WHAT WE FOUND OUT:

COMMENTS OF OTHER CHILDREN: ABOUT WHAT WE FOUND OUT

CHILDREN'S SCIENCE WORKSHEET

NAMES: CLASS:

SCHOOL:

TOPIC:

QUESTION:

ANSWER(S): WHICH WE ARE GOING TO CHECK ON

HOW TO CHECK IF IT IS A GOOD ANSWER(S) OR A BAD ANSWER

ASK SOMEONE: Name of person or people

READ ABOUT IT: What we could read

DO SOMETHING TO FIND OUT: What we could do

WHAT WE FOUND OUT IN OUR INVESTIGATIONS

CHILDREN'S SCIENCE WORKSHEET

NAMES:

TOPIC:

QUESTION:

WHAT WE THINK ARE SOME SENSIBLE ANSWERS

Answer number

Reason

WHAT WE WOULD LIKE TO INVESTIGATE NOW

What we want to ask someone:

Who we could ask:

What we want to read about:

What we think we could do:

METAL

WHAT IS METAL?

Is it iron? Is it hard, silvery stuff? It can be, but it is more than these. So far 82 different things have been found which we call metal. Some of these can be joined together to make new 'metals'. In the diagram you can see the names of some common metals. You can also see how some may be joined together to make new metals or alloys as they are called. (The diagram is on the next page.) You can see from the diagram that steel is made from iron (by adding carbon).

Did you know that the 'lead' in a pencil is not really lead. It is graphite which is a form of carbon, and this is not a metal. (Soot and diamonds are other forms of carbon.)

You may be interested to know that three of the metals are called precious metals. They are gold, silver and platinum.

HOW CAN YOU TELL IF SOMETHING IS MADE OUT OF METAL?

You can not always tell by the colour. Gold and copper are quite different in colour from, say, aluminium and lead. You can not tell by the weight of it because some pieces of metal are quite light, such as the foil that food is sometimes cooked in. You can not tell by whether or not it sticks to a magnet because only iron, or things that have iron in them, will stick to a magnet. You can not tell by whether or not it is hard because some things do not seem to feel hard, such as a Steelo pot cleaner. (If you tried to bite them with your teeth you would find that metals are quite hard though.) The best ways to tell if something is made out of metal or not are:

(i) if it is not already shiny, then scrape it with a file or sandpaper and see if it shines (it should),

(ii) see if electricity goes through it (it should),

(iii) bang it and see if it gives out a sound (most metals do).

SOME TYPES OF METALS

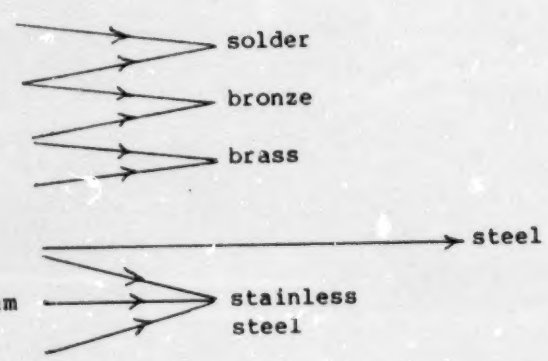
PRECIOUS METALS

- gold
- silver
- platinum

SOME COMMON METALS

- mercury
- aluminium
- lead
- tin
- copper
- zinc
- iron
- chromium
- nickel
- titanium
- magnesium
- manganese
- uranium

SOME ALLOYS



WHERE DOES METAL COME FROM, AND HOW IS IT MADE?

Metals mostly come from different kinds of rock. They are mixed in with the rock. In fact there may be more than one metal in a piece of rock, and the metals themselves are often mixed together as alloys.

Sometimes the rock is on or near the surface (top) of the earth; sometimes it is underground. If it is near the surface then machines are used to scoop up the rock that contains the metal. When it is underground, mines have to made to get it out.

Sometimes the rock has already been broken or crushed up by nature and the metal (for example, iron or gold) is amongst the sand. If people want the metal and it is still in the rock then they have to crush up the rock and use special ways to get the metal out. They use different ways for different metals; sometimes they use chemicals and sometimes they make the mixture very, very hot so that the metal melts and runs out.

You may also be surprised to know that metals are also found at the bottom of the sea, and in the sea water itself, but they are hard to get from these places.

Nobody really invented metals. They are there in nature. Volcanoes seem to have brought them up from inside the earth. People have known about some metals for hundreds and hundreds of years. Long ago there was a Bronze Age and an Iron Age. The Greeks and Romans knew a number of common metals such as lead, tin, mercury, gold, silver, copper and iron.

How people first found out about metals is an interesting question. Perhaps by chance they lit a fire on some rock that had metal in it. If a wind made the fire so hot that the metal melted then the people could have found the shiny metal among the ashes. We can only guess about this because we don't really know.

What people have invented are ways to get the metal out of the rock in which it is found. They have also discovered ways to get it apart from other metal to which it may be stuck.

Metals are found in most countries, but not every country has every type of metal. New Zealand has some iron which comes from the ironsands along the west coast of the North Island. We also have some titanium and there is still a little gold and possibly a little copper left. There are small amounts of some other metals as well. Most of the metals that we use have to come from other countries.

WHAT ARE METALS USED FOR?

Metals are a bit different from each other in a number of ways and so they are used for different things. Some examples of what different metals are used for are shown in the chart.

METAL	USED FOR	REASON
gold	jewellery	a soft metal that is easy to shape
stainless steel	knives, forks, spoons	doesn't rust
aluminum	aeroplanes power lines	light metal, doesn't rust conducts electricity well
lead	fishing line sinkers	a heavy metal
copper	bottom of pots electric wires	conducts heat very well conducts electricity well
steel	tools, e.g. hammer buildings	a hard metal a strong metal
mercury	thermometer	it is a liquid
tin	coating thin steel cans	doesn't rust

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